

IB intensities in EC decay of  $^{125}\text{I}$ P G Sabu<sup>+</sup> and M T Rama Rao<sup>++</sup><sup>+</sup> Department of Physics, M A M O College, Mookom, Calicut, Kerala-673 602  
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**Abstract** : The internal bremsstrahlung (IB) spectrum from the allowed electron capture (e.c.) decay of  $^{125}\text{I}$  leading to the 35 KeV level of  $^{125}\text{Te}$  was studied using a  $2'' \times 2''$  NaI (TI) scintillation detector and a PC based multichannel analyser. The unfolding method was applied for deriving true IB spectrum, and a modified Jauch's plot was drawn in view of intense  $2p$ -capture admixed with  $1s$ . Through an iteration technique, the  $1s$  end-point energy was determined as  $80 \pm 1.6$  keV. The intensities evaluated on the basis of Glauber and Martin (GM) and Intemann theories coincided with the experimental intensities for most part of the IB spectrum.

**Keywords** : Internal bremsstrahlung spectrum, end-point energy, intensities

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The IB theories, experimental methods and procedures of analysis were extensively reviewed by Bambynek *et al* [1]. When the transition energy is low, the IB is admixed with  $1s$ ,  $2s$ ,  $2p$  and  $3p$  and in such cases, a modified Jauch's plot as suggested by Bambynek *et al* [1] and as reported by Babu and Rama Rao [2], (Sr) Little Flower *et al* [3] is to be adopted instead of a simple linearised Jauch's plot. The e.c. decay of  $^{125}\text{I} \rightarrow ^{125}\text{Te}$  has a low transition energy. Wapstra and Gove's [4] mass tables show a value of  $147.5 \pm 1.0$  keV (taken from e.c. measurements), while Wapstra and Audi's [5] revised tables show a value of  $177 \pm 2$  keV (from the available IB values) for the ground-to-ground state decay energy of  $^{125}\text{I} \rightarrow ^{125}\text{Te}$ . (Sr) Little Flower *et al*'s [3] IB theoretical intensities, the only ones available in literature, did not agree with the theoretical estimates. With a view to testing the agreement or otherwise of the experimental and theoretical IB intensities, it was felt desirable to remeasure the end-point energy and re-estimate the intensities. The results obtained in the present work appeared in the *Proc. of Conference* [6].

The IB detector (integral assembly of  $2'' \times 2''$  NaI (TI) scintillator coupled to an RCA 4523 photomultiplier), a PC based MCA (MC 1002) and the electronic assembly, all supplied

by Nucleonix, Hyderabad were used in the present investigations. The details of the experimental set-up were given in Ref [6].

The decay scheme of  $^{125}\text{I}$  to  $^{125}\text{Te}$  is well established [7].  $^{125}\text{I}$  decays (100%) to the 35 keV level of  $^{125}\text{Te}$  without any ground-to-ground transition. This is an allowed transition with  $\Delta J = 1$  and without any change in parity ( $5/2^+ \rightarrow 3/2^+$ ). When  $^{125}\text{Te}$  comes to its ground state from 35 keV level, a  $\gamma$ -ray of energy 35 keV is emitted. In addition, K-X-rays of 28 keV are also emitted from this isotope.

A carrier-free and nearly point source of 5  $\mu\text{Ci}$  activity of  $^{125}\text{I}$  supplied from BRIT, BARC, Bombay was used in the present investigations. The spectra with and without the source were recorded alternatively and the counts were pooled up for a total period of 70 hours each. The raw IB spectrum obtained after subtracting the background and the pile-up counting rates arising due to the presence of strong 35 keV and 28 keV X-rays from the measured counting rate, was analyzed from 40 keV to 105 keV. Following Liden and Starfelt [8] procedure, the true IB spectrum was obtained as shown in Figure 1. The modified Jauch's plot  $\{[N(E)]/[E \times R_{1s}(E) \times f(E)]\}^{1/2}$  vs  $E$  as shown in Figure 2 was drawn for obtaining  $1s$  endpoint energy ( $Q_{1s}$ ). Here,

$$f(E) = 1 + \frac{P_{L_{11-111}}}{P_k} \times \frac{[Q_{2p}]^2}{R_{1s}(E)} \times \left[ 1 + \frac{K_{Kx}}{(q_{1s} - E)} \right]^2$$

$R_{1s}(E) = 0.43$  evaluated using Intemann's [9] expression,  $[P_{L_{11-111}}]/P_k = 0.254 \pm 0.005$  taken as an average of the two consistent available values from Leutz and Zeigler [10] and

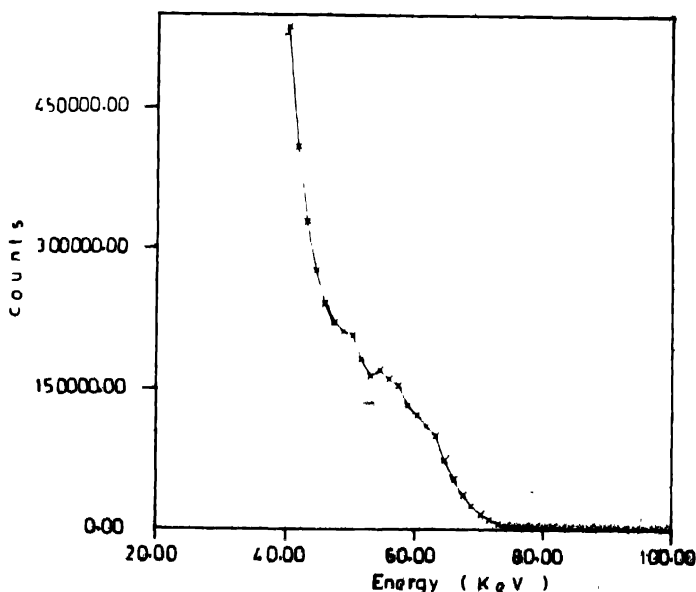


Figure 1. True IB spectrum of  $^{125}\text{I}$ .

Smith and Lewis [11],  $Q_{2p}$  evaluated from GM theory and  $K_{Kx}$  = difference in binding energies of  $2p$  and  $1s$  electrons of  $^{125}\text{Te} = 28.47$  keV taken from Shirley *et al* [12] were used

for obtaining the modified Jauch's plot. Through successive iterations, the  $1s$  endpoint energy was determined as  $80 \pm 1.6$  keV. A maximum error of 2% was assigned which may arise due to errors in counting statistics, other systematic errors during unscrambling of the spectrum and the error in  $[P_{L11-111}]/P_K$ . Taking the  $K$ -shell binding energy of 33.17 keV from Shirley *et al* [12] the transition energy to the ground level of  $^{125}\text{Te}$  was deduced as  $148.17 \pm 1.6$  keV.

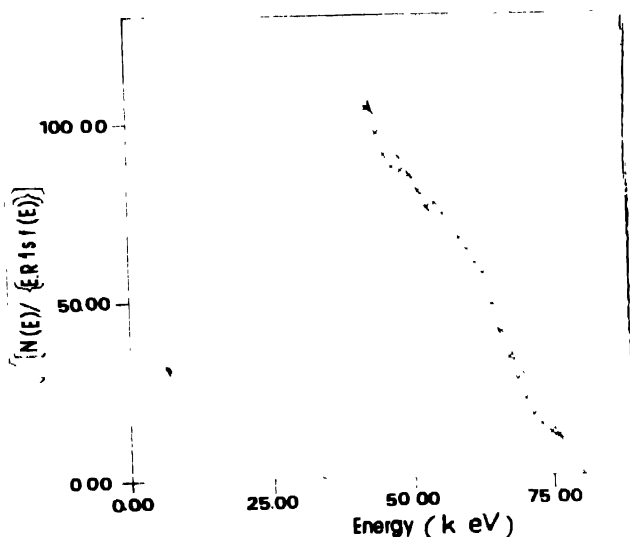


Figure 2. Jauch's plot of  $^{125}\text{I}$  (The intercept of the least-squares fitted straight line yielded  $q_{1s} = 80 \pm 1.6$  keV.)

The presently measured value of decay energy agrees fairly well with that of Wapstra and Gove [4] and deviates somewhat (by about 30 keV) from the earlier IB estimates [5]. Among the earlier IB measurements, only (Sr) Little Flower *et al* [3] have considered  $2p$  IB, while others determined the endpoint energy from a simple Jauch's plot [1]. (Sr) Little Flower *et al* [3] adopted folding technique for their analysis of IB spectrum. Lancman and Bond [13] pointed out that the end-point energy values derived from such a fitting procedure can vary even as much as 25 keV with different assumed spectral shapes. It may also be noticed that (Sr) Little Flower *et al*'s evaluation of experimental IB intensities did not agree with the theoretical GM intensities. This prompted us to adopt the unfolding method for determining the  $1s$  endpoint energy, which is also in accordance with the recommendations of Bambynek *et al* [1] for the procedures of IB analysis.

Integrated experimental IB intensities per  $K$ -capture e.c. decay were evaluated and compared with corresponding theoretical estimates. The Morrison-Schiff (MS) theoretical  $1s$  intensities were multiplied with  $R_{1s} = 0.43$  and the screening correction  $S_{1s} = 0.96$  obtained from MG theory. Similarly, the GM  $2p$  theoretical intensities were multiplied with the

screening correction  $S_{2p} = 0.67$  of MG theory. These two are added up with their weightage factors  $P_K$  and  $P_L$ . The values thus obtained are shown in Table 1. The main sources of error in the experimental intensities arise from the uncertainties in the source strength evaluation (10%), errors in counting statistics (1 to 2% in the range from 40 keV to 70 keV and 5 to 10% above 70 keV) and also systematic errors associated with corrections applied to unfold the spectrum (2%). Thus, a total error of 14% was assigned on the experimental intensities for the ranges of energy 40-105 keV and 60-105 keV and 20% for the range 80-105 keV. The error in the theoretical intensities were due to the uncertainties of 2% in  $P_L/P_K$  and of 2% uncertainty in end-point energies. Thus, a total error of 4% was assigned to the theoretical estimates. It can be noticed from Table 1 that the experimental intensities agree fairly well with theoretical estimates in a wide range of energy except near the endpoint energy. With a sufficiently large number of counts in the range above 80 keV also, better agreement with the theory might be achieved. A good agreement with the theory for the most prominent part of the IB spectrum in the present investigations is in accordance with the observations of Sanjeevaiah and Sanjeevaiah [14] and Kader *et al* [15] and is against the observations made by (Sr) Little Flower *et al* [3].

**Table 1.** Integrated theoretical and experimental IB intensities.

Sl No	Range of energy (KeV)	$(N_{1s})_{th}$	$(N_{2p})_{th}$	$(N_{Total})_{th}$	$(N)_{exptal}$
1	40-105	$3.224 \times 10^{-4}$	$1.555 \times 10^{-2}$	$(3.514 \pm 0.141) \times 10^{-3}$	$(3.145 \pm 0.44) \times 10^{-3}$
2	60-105	$5.44 \times 10^{-5}$	$2.274 \times 10^{-3}$	$(5.195 \pm 0.208) \times 10^{-4}$	$(4.575 \pm 0.641) \times 10^{-4}$
3	80-105	-----	$2.81 \times 10^{-4}$	$(2.81 \pm 0.56) \times 10^{-4}$	$(1.043 \pm 0.209) \times 10^{-5}$

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